Developing a Trophic Mass Balance Model of the Eastern Chukchi Sea

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Objectives

- Construct a trophic mass balance ecosystem model capturing the trophic organization of the eastern Chukchi Sea.
- Identify key uncertainties in trophic interactions and unexplained mortality.

Figure 1. Model area in the eastern Chukchi Sea.

Table 1. Out-of-balance functional groups with trophic level (TL), biomass (tons/km^2), and ecotrophic efficiency (EE).

Functional Group	TL	Biomass	EE
Bearded seal	3.9	0.04	5.21
Wintering seals	4.3	0.06	2.04
Small Sculpin	3.9	0.01	1.04
Misc. Shallow Fish	3.6	0.008	1.50
Pollock	3.5	0.002	3.02
Pacific Cod	3.6	0.002	3.15
Saffron Cod	3.6	0.04	3.58
Arctic Cod	3.5	0.30	3.19
Misc. Crabs	3.1	0.21	4.95
Benthic Amphipods	2.5	33.90	1.04
Worms, etc.	2.5	34.70	2.05

Methods

The model was built using the Ecopath framework (Christensen and Pauly 1992). The area covered is about 195,000 km^2 of the eastern Chukchi Sea continental shelf between Bering Strait and Pt. Barrow at depths less than 70m (Figure 1). The base time period for the model is 1990. The model provides an annual snapshot of trophic interactions.

- **Functional groups** We sought to represent species individually, however when information was sparse species were aggregated into functional groups with similar species having similar life histories and food habits. A total of 58 functional groups were identified, 48 living, 2 detritus, and 8 harvest or fishing.
- **Mammals and Seabirds** Model parameters and population estimates were derived from bibliographic sources and consultation with experts.
- **Fish and epibenthic invertebrates** Biomass estimates were derived from a 1990 bottom trawl survey of the northeastern Chukchi Sea conducted by MMS (Barber et al. 1997).
- **Benthic invertebrates, zooplankton, phytoplankton, and microbes** All model parameters were derived from published literature.

References

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Preliminary Results from Initial Balancing

- The vast majority of biomass is in benthic invertebrates at trophic level (TL) ≈ 2.5 (Figure 2).
- The top predator is the polar bear harvest (TL = 6.2), followed by the Alaskan beluga (TL = 5.5) and seal subsistence harvest (TL = 5.3). The top predators from living groups are polar bears (TL = 5.2), beluga whales (TL = 4.5), large-mouth flatfish (TL=4.5), piscivorous seabirds (TL = 4.4), and wintering seals (TL = 4.3).

Out-of-balance Functional Groups

- With initial parameters and diets, not all functional groups are in balance. Eleven of the functional groups have an ecotrophic efficiency (EE) >1, indicating that mortality within the model exceeds production (Table 1).
- Biomass estimates and sources of mortality for bearded and wintering (ringed and spotted) seals are uncertain. An underestimation of their biomass could result in the excess mortality observed, as could uncertainties in polar bear biomass and diet.
- For bearded seals the greatest source of mortality is from the subsistence harvest. While for wintering seals polar bears are their greatest source of mortality.
- For the out-of-balance fish groups key uncertainties come from both predator diets and biomass above and from the source of biomass estimates of the fish groups.
- Most of the excess crab mortality is from predation by sea stars.
- A lack of system specific data may contribute to the high EE's of benthic amphipods and worms. Biomass estimates for both of these groups are adapted from mean density estimates that reflect the combined Chukchi and Bering Sea continental shelf (Stoker 1981).

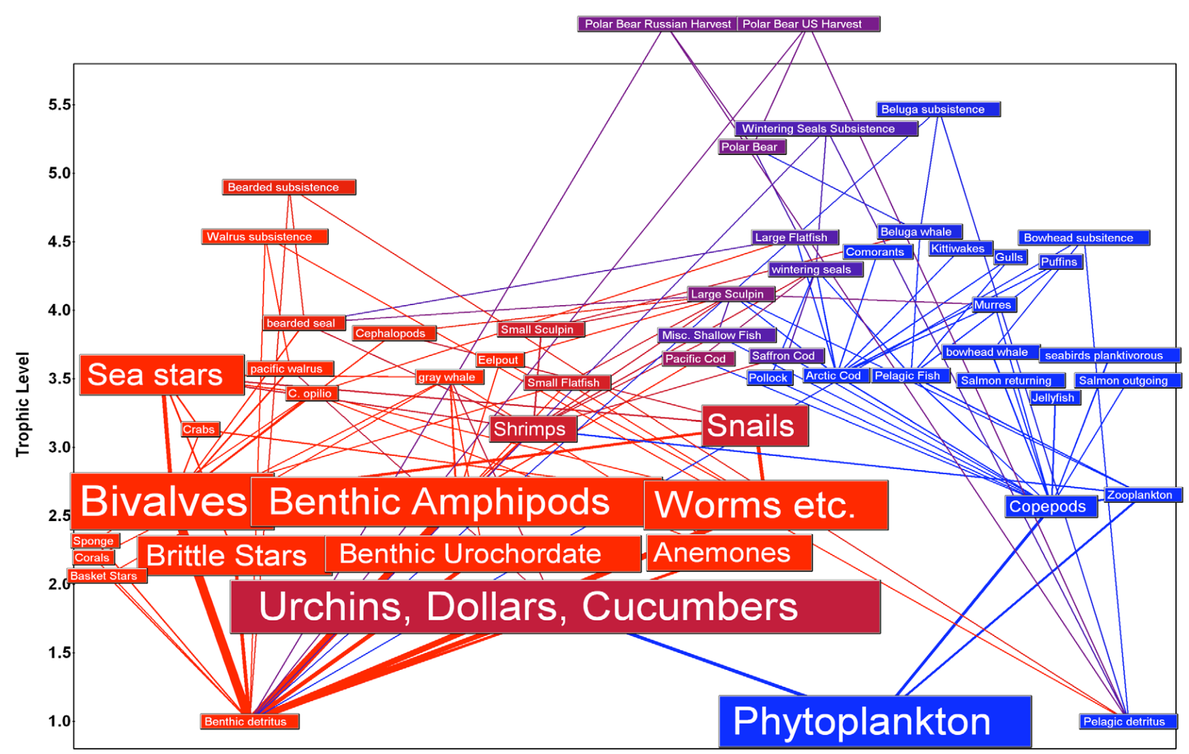

Figure 2. Chukchi Sea food web organized from top to bottom by trophic level and left to right by benthic pathwayin red and pelagic pathway in blue. The size of the box is proportional to the biomass and the width of the line is proportional to the exchange between groups.